INDOOR AIR QUALITY ASSESSMENT

Bryantville Elementary School
29 Gurney Drive
Pembroke, Massachusetts

Prepared by:
Massachusetts Department of Public Health
Center for Environmental Health
Bureau of Environmental Health Assessment
Emergency Response/Indoor Air Quality Program

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Background/Introduction

At the request of the Pembroke Board of Health, the Massachusetts Department of Public Health (MDPH), Center for Environmental Health's (CEH), Bureau of Environmental Health Assessment (BEHA) provided assistance and consultation regarding indoor air quality concerns at the Bryantville Elementary School (BES), 29 Gurney Drive, Pembroke, Massachusetts. Concerns about odors generated by the application of a spray-on rubber membrane material to the cafeteria ceiling and the potential impact on occupants of the building prompted the request. On December 9, 2004, Cory Holmes, an Environmental Analyst in BEHA's Emergency Response/Indoor Air Quality (ER/IAQ) Program, conducted a walkthrough of the building and performed testing related to these odors. These findings are described later in this report, in the *Cafeteria Renovations Project* section. Mr. Holmes returned to the BES on January 19, 2005 to conduct a more comprehensive indoor air quality assessment of the building.

MDPH had previously visited the school on March 5, 2002 to investigate concerns about pollutants generated by renovation activities. A report was issued detailing air quality conditions specifically related to these activities in the school at that time (MDPH, 2002).

Methods

Air tests for carbon dioxide, carbon monoxide, temperature and relative humidity were taken with the TSI, Q-TRAK™ IAQ Monitor, Model 8551. Air tests for airborne particle matter with a diameter less than 2.5 micrometers were taken with the TSI, DUSTTRAK™ Aerosol Monitor Model 8520. Screening for total volatile organic compounds (TVOCs) was conducted using a Thermo Environmental Instruments Inc., Model 580 Series Photo Ionization Detector (PID). MDPH staff also performed visual inspections of building materials for water damage and/or microbial growth.

Results

The school houses approximately 600 students in first through sixth grade and has approximately 40 staff members. Tests specifically related to the potential off-gassing of materials used in the cafeteria (i.e., TVOCs) were taken on December 9, 2004. At the time the building was unoccupied, per order of the Pembroke Board of Health. These results are presented in Table 1. Tests on January 19, 2005 included TVOCs, as well as other indoor air quality parameters described in the Methods portion of the report, were taken during normal operations and are listed in Table 2.

Discussion

Cafeteria Renovations Project

As a result of mold growth on ceiling materials in the cafeteria, a number of remediation activities were undertaken. Fiberglass insulation was removed and the material under the roof (gypcrete) was reportedly disinfected with an antimicrobial agent. The cafeteria was sealed off during remediation to prevent exposure to building occupants while the waterproofing cured.

To create a water impermeable barrier, the school's contractor applied a latex rubber membrane to the gypcrete. This latex membrane is created when a spray product, Procor®, is applied to a surface. Procor® contains a number of VOCs (Grace, 2000). These VOCs are carbon-containing substances that have the ability to evaporate at room temperature. Frequently, exposure to low levels of VOCs may produce eye, nose, throat and/or respiratory irritation in some sensitive individuals.

The Pembroke School Department (PSD) hired an environmental consultant, Covino Associates (Covino) to conduct air testing and monitoring for VOCs, while the cafeteria ceiling project was in progress. Testing conducted on November 15, 2004 revealed no presence of VOCs (Covino, 2004a). Further air sampling for carbon disulfide (an odorous component of the membrane material) was conducted by Covino on November 24, 2004. Lab results detected trace amounts of carbon disulfide in the cafeteria and the hallway near the janitor's closet. The carbon disulfide may have been responsible for the reported odors. The minimum detection limit as indicated from the laboratory report is 0.01 parts per million (ppm) of air; levels in the cafeteria and janitor's closet hallway measured 0.014 and 0.011 ppm respectively (Covino, 2004b). The odor threshold for carbon disulfide ranges from 0.02 ppm to 0.1 ppm (ATSDR, 2004).

On Friday December 3, 2004, the containment for the cafeteria was reportedly dismantled. Materials released from within the cafeteria that had been contained likely led to occupant complaints. Shortly after the dismantling of the containment odors were once again realized and the area was subsequently resealed. As discussed, MDPH staff conducted additional air testing on December 9, 2004 in order to assess whether containment measures were effective in preventing pollutant migration from the cafeteria into occupied areas of the building. Tests for TVOCs were taken at several locations inside the building believed to be impacted by odors (e.g., inside the cafeteria and surrounding hallways) as well as areas not directly impacted by odors (i.e., classrooms and offices throughout the building). Background tests for TVOCs were taken outside for comparison to indoor levels. Outdoor TVOC concentrations were non-detectable or ND on December 9, 2004 (Table 1). Indoor TVOC concentrations throughout the building, including the cafeteria were also ND during both days of testing. These results were verbally communicated to both school and local health officials. Ultimately, a representative from W.R. Grace, the manufacturer of Procor®, suggested the complete removal of the material. Removal of the Procor® material was conducted during Christmas break and completed prior to reoccupancy of the building on January 3, 2005.

Following the Procor® removal, MDPH staff returned to the BES on January 19, 2005. TVOC testing was again conducted in a manner similar to that described previously. Outdoor TVOC concentrations were ND (Table 2). Indoor TVOC concentrations throughout the building, including the cafeteria were also ND. These results were also verbally communicated to both school and local health officials.

It is important to note that during both MDPH assessments the cafeteria was sealed using plastic polyethylene sheeting and duct tape on the interior, as well as the exterior of cafeteria doors to provide a duel barrier (Pictures 4 and 5). To enhance containment, an airlock or pressurized buffer zone was created by sealing off and mechanically introducing large amounts of outside air into the corridor outside the cafeteria (Pictures 6 and 7).

Ventilation

It can be seen from Table 2 that carbon dioxide levels were above 800 parts per million (ppm) in ten of twenty-five areas surveyed, indicating inadequate air exchange in some areas. Fresh air in classrooms is mechanically supplied by unit ventilator (univent) systems (Picture 1). A univent draws air from outdoors through a fresh air intake located on the exterior wall of the building (Picture 2) and returns air through an air intake located at the base of the unit. Fresh and return air are mixed, filtered, heated and provided to classrooms through an air diffuser located in the top of the unit (Figure 1). Univents were found activated in all but one classroom surveyed. To function as designed, univents must be activated while classrooms are occupied.

Exhaust ventilation in classrooms is provided by ducted, grated ceiling or wall vents (Picture 3) powered by rooftop motors. These vents were operating during the assessment. It is important to note however, that the location of some exhaust vents can limit exhaust efficiency. In several areas exhaust vents are located above hallway doors (Picture 3). When classroom doors are open, exhaust vents will tend to draw air from both the hallway and the classroom, reducing the effectiveness of the exhaust vent to remove common environmental pollutants.

Mechanical ventilation in common areas such as the main office, gymnasium and cafeteria is provided by rooftop air-handling units (AHUs) connected to ceiling or wall-mounted air diffusers via ductwork. Return air is drawn into wall or ceiling exhaust vents and ducted back to the AHU. These systems were also functioning during the assessment.

To maximize air exchange, the MDPH recommends that both supply and exhaust ventilation operate continuously during periods of school occupancy. In order to have proper ventilation with a mechanical supply and exhaust system, the systems must be balanced to provide an adequate amount of fresh air to the interior of a room while removing stale air from the room. It is recommended that HVAC systems be re-balanced every five years (SMACNA, 1994). The initial equipment balancing should have occurred after the installation of the new HVAC systems in 2003.

The Massachusetts Building Code requires that each room have a minimum ventilation rate of 15 cubic feet per minute (cfm) per occupant of fresh outside air or openable windows (SBBRS, 1997; BOCA, 1993). The ventilation must be on at all times that the room is occupied. Providing adequate fresh air ventilation with open windows and maintaining the temperature in the comfort range during the cold weather season is impractical. Mechanical ventilation is usually required to provide adequate fresh air ventilation.

Carbon dioxide is not a problem in and of itself. It is used as an indicator of the adequacy of the fresh air ventilation. As carbon dioxide levels rise, it indicates that the ventilating system is malfunctioning or the design occupancy of the room is being exceeded. When this happens, a buildup of common indoor air pollutants can occur, leading to discomfort or health complaints. The Occupational Safety and Health Administration (OSHA) standard for carbon dioxide is 5,000 parts per million parts of air (ppm). Workers may be exposed to this level for 40 hours/week, based on a time-weighted average (OSHA, 1997).

The Department of Public Health uses a guideline of 800 ppm for publicly occupied buildings. A guideline of 600 ppm or less is preferred in schools due to the fact that the majority of occupants are young and considered to be a more sensitive population in the evaluation of environmental health status. Inadequate ventilation and/or elevated temperatures are major causes of complaints such as respiratory, eye, nose and throat irritation, lethargy and headaches. For more information concerning carbon dioxide, please consult Appendix A.

Temperature measurements ranged from 66° F to 75° F, which were below or at the lower end of the MDPH comfort guidelines in a number of areas (Table 2). The MDPH recommends that indoor air temperatures be maintained in a range of 70 ° F to 78 ° F in order to provide for the comfort of building occupants. In many cases concerning indoor air quality, fluctuations of temperature in occupied spaces are typically experienced, even in a building with an adequate fresh air supply.

The relative humidity measurements in the building ranged from 13 to 24 percent, which were below the MDPH recommended comfort range (Table 2). The MDPH recommends a comfort range of 40 to 60 percent for indoor air relative humidity. Relative humidity levels in the building would be expected to drop during the winter months due to heating. The sensation of dryness and irritation is common in a low relative humidity environment. Low relative humidity is a very common problem during the heating season in the northeast part of the United States.

Microbial/Moisture Concerns

As previously discussed, mold growth occurred on ceiling materials in the cafeteria. Over the course of time, a number of remediation activities were taken to address these concerns. No other moisture related problems were communicated or observed in the school at the time of this assessment.

Other Concerns

Indoor air quality can be adversely impacted by the presence of respiratory irritants, such as products of combustion. The process of combustion produces a number of pollutants. Common combustion products include carbon monoxide, carbon dioxide, water vapor and smoke (fine airborne particle material). Of these materials, exposure to carbon monoxide and particulate matter with a diameter of 2.5 micrometers (μm) or less (PM2.5) can produce immediate, acute health effects upon exposure. To determine whether combustion products were present in the school environment, BEHA staff obtained measurements for carbon monoxide and PM2.5.

Carbon monoxide is a by-product of incomplete combustion of organic matter (e.g., gasoline, wood and tobacco). Exposure to carbon monoxide can produce immediate and acute health affects. Several air quality standards have been established to address carbon monoxide pollution and prevent symptoms from exposure to these substances. The MDPH established a corrective action level concerning carbon monoxide in ice skating rinks that use fossil-fueled ice resurfacing equipment. If an operator of an indoor ice rink measures a carbon monoxide level over 30 ppm, taken 20 minutes after resurfacing within a rink, that operator must take actions to reduce carbon monoxide levels (MDPH, 1997).

ASHRAE has adopted the National Ambient Air Quality Standards (NAAQS) as one set of criteria for assessing indoor air quality and monitoring of fresh air introduced by HVAC systems (ASHRAE, 1989). The NAAQS are standards established by the US EPA to protect the public health from 6 criteria pollutants, including carbon monoxide and particulate matter (US EPA, 2000a). As recommended by ASHRAE, pollutant levels of fresh air introduced to a building should not exceed the NAAQS (ASHRAE, 1989). The NAAQS were adopted by reference in the Building Officials & Code Administrators (BOCA) National Mechanical Code of 1993 (BOCA, 1993), which is now an HVAC standard included in the Massachusetts State Building Code (SBBRS, 1997). According to the NAAQS established by the US EPA, carbon monoxide levels in outdoor air should not exceed 9 ppm in an eight-hour average (US EPA, 2000a).

Carbon monoxide should not be present in a typical, indoor environment. If it *is* present, indoor carbon monoxide levels should be less than or equal to outdoor levels. Outdoor carbon monoxide concentrations were ND (Table 2). Carbon monoxide levels measured throughout the school were also ND.

The US EPA also established NAAQS for exposure to particulate matter. Particulate matter is airborne solids that can be irritating to the eyes, nose and throat. The NAAQS originally established exposure limits for particulate matter with a diameter of 10 μm or less (PM10). According to the NAAQS, PM10 levels should not exceed 150 micrograms per cubic meter ($\mu g/m^3$) in a 24-hour average (US EPA, 2000a). This standard was adopted by both ASHRAE and BOCA. Since the issuance of the ASHRAE standard and BOCA Code, US EPA proposed a more protective standard for fine airborne particles. This more stringent, PM2.5 standard requires outdoor air particulate levels be maintained below 65 $\mu g/m^3$ over a 24-hour average (US EPA, 2000a). Although both the ASHRAE standard and BOCA Code adopted the PM10 standard for evaluating air quality, BEHA uses the more protective proposed PM2.5 standard for evaluating airborne particulate matter concentrations in the indoor environment.

Outdoor PM2.5 concentrations were measured at 23 μg/m^3 (Table 2). PM2.5 levels measured indoors ranged from 9 to 19 μg/m^3. PM2.5 measurements were below background in all areas and well below the NAAQS of 65 μg/m^3. Frequently, indoor air levels of particulates (including PM2.5) can be at higher levels than those measured outdoors. A number of mechanical devices and/or activities that occur in schools can generate particulate during normal operations. Sources of indoor airborne particulates may include but are not limited to particles generated during the operation of fan belts in the HVAC system, cooking in the cafeteria stoves and microwave ovens; use of photocopiers, fax machines and computer printing devices; operation of an ordinary vacuum cleaner and heavy foot traffic indoors.

As discussed, indoor air quality can also be negatively influenced by the presence of materials containing volatile organic compounds (VOCs). TVOC testing was discussed previously under the *Cafeteria Renovations Project* section of this assessment. Indoor TVOC levels were ND for both assessment dates. Please note, TVOC air measurements are only reflective of the indoor air concentrations present at the time of sampling. Indoor air concentrations can be greatly impacted by the use TVOC containing products. While no TVOC levels measured exceeded background levels, materials containing VOCs were present in the school. A number of classrooms also contained dry erase boards and dry erase markers. Materials such as dry erase markers and dry erase board cleaners may contain VOCs, (e.g. methyl isobutyl ketone, n-butyl acetate and butyl-cellusolve) (Sanford, 1999), which can be irritating to the eyes, nose and throat. Cleaning products were found in unlocked cabinets below sinks and on countertops in several classrooms. Cleaning products also contain chemicals that can be irritating to the eyes, nose and throat and should be kept out of reach of students.

In an effort to reduce noise from sliding chairs, tennis balls had been sliced open and placed on chair legs (Picture 8). Tennis balls are made of a number of materials that are a source of respiratory irritants. Constant wearing of tennis balls can produce fibers and off-gas TVOCs. Tennis balls are made with a natural rubber latex bladder, which becomes abraded when used as a chair leg pad. Use of tennis balls in this manner may introduce latex dust into the school environment. Some individuals are highly allergic to latex (e.g., spina bifida patients) (SBAA, 2001). It is recommended that the use of materials containing latex be limited in buildings to reduce the likelihood of symptoms in sensitive individuals (NIOSH, 1997). A question and answer sheet concerning latex allergy is attached as Appendix B (NIOSH, 1998).

Conclusions/Recommendations

At the time of the second MDPH assessment on January 19, 2005 the roofing material had been completely removed and no odors were detected. The cafeteria however, remained sealed and depressurized in anticipation of future renovation activities. In view of the findings at the time of the visit, the following recommendations are divided into those specific to renovation work and those made to improve general indoor air quality:

Renovations

MDPH suggests that the majority of these steps be taken on any renovation project within a public building.

1. Continue to use local exhaust ventilation and isolation techniques to control for renovation pollutants. Caution should be taken to prevent the *re-entrainment* of these materials into the building's HVAC system. The design of each system must be assessed to determine how it may be impacted by renovation activities. Specific HVAC protection requirements pertain to the return, central filtration and supply components of the ventilation system. This may entail shutting down systems (when possible) during periods of heavy construction and demolition, ensuring systems are isolated from contaminated environments, sealing ventilation openings with plastic and utilizing filters with a higher dust spot efficiency where needed (SMACNA, 1995).
2. Seal spaces in roof decking and/or any remaining utility holes in walls adjacent to construction/renovation activities to prevent/reduce pollutant pathways of migration.
3. Designate a single responsible individual (as well as an alternate) to conduct daily inspections of construction barriers to ensure integrity is maintained.
4. Establish communications between all parties involved with building renovations to prevent potential IAQ problems. Develop a forum for occupants to express concerns about renovations as well as a program to resolve IAQ issues.
5. Develop a notification system for building occupants immediately adjacent to construction activities to report construction/renovation related odors and/or dusts

problems to the building administrator. Have these concerns relayed to the contractor in a manner to allow for a timely remediation of the problem.

6. Schedule projects which produce large amounts of dusts, odors and emissions during unoccupied periods or periods of low occupancy, when possible.
7. Disseminate scheduling itinerary to all affected parties, this can be done in the form of meetings, newsletters or weekly bulletins.
8. Obtain Material Safety Data Sheets (MSDS) for all construction materials used during renovations and keep them in an area that is accessible to all individuals during periods of building operations as required by the Massachusetts Right-To-Know Act (MGL, 1983).
9. Consult MSDS' for any material applied to the effected area during renovation(s) including any sealant, carpet adhesive, tile mastic, flooring and/or roofing materials. Provide proper ventilation and allow sufficient curing time as per the manufacturer's instructions concerning these materials.
10. Relocate susceptible persons and those with pre-existing medical conditions (e.g., hypersensitivity, asthma) away from areas of renovations, if possible.
11. Implement prudent housekeeping and work site practices to minimize exposure to renovation pollutants. Consider increasing manpower or work hours to accommodate increase in dirt, dust accumulation due to construction/renovation activities. This may include constructing barriers, sealing off areas, and temporarily relocating furniture and supplies. To control for dusts, a high efficiency particulate air filter (HEPA) equipped vacuum cleaner in conjunction with wet wiping of all surfaces is recommended.

12. Close windows adjacent to construction activities to prevent unfiltered air from entering the building.
13. Consider changing HVAC filters more regularly in areas impacted by renovation activities. Examine the feasibility of acquiring more efficient filters for these units.

General Indoor Air Quality

1. Continue to operate both supply and exhaust ventilation continuously during periods of school occupancy to maximize air exchange. Consult with the school's heating, ventilation and air conditioning (HVAC) engineer concerning an increase in the introduction of outside air.
2. Remove all blockages from univents and exhaust vents to ensure adequate airflow. Close classroom doors to improve exhaust ventilation.
3. Consider adopting a balancing schedule of every 5 years for mechanical ventilation systems, as recommended by ventilation industrial standards (SMACNA, 1994).
4. Implement prudent housekeeping. For buildings in New England, periods of low relative humidity during the winter are often unavoidable. Therefore, scrupulous cleaning practices should be adopted to minimize common indoor air contaminants whose irritant effects can be enhanced when the relative humidity is low. To control for dusts, a high efficiency particulate arrestance (HEPA) filter equipped vacuum cleaner in conjunction with wet wiping of all surfaces is

recommended. Drinking water during the day can help ease some symptoms associated with a dry environment (throat and sinus irritations).

5. Ensure plants are equipped with drip pans. Avoid over-watering and examine drip pans periodically for mold growth. Disinfect with an appropriate antimicrobial where necessary. Plants should also be located away from the air stream of univents.
6. Store cleaning products properly and out of reach of students. Ensure spray bottles are properly labeled in case of emergency.
7. Consider discontinuing the use of tennis balls on chair/desk legs to prevent latex dust generation. Alternative "glides" can commonly be purchased from office supply stores, see Picture 9 for an example.
8. Consult "Mold Remediation in Schools and Commercial Buildings" published by the US EPA (US EPA, 2001) for further information on mold and/or mold clean up. Copies of this document are available from the US EPA at: http://www.epa.gov/iaq/molds/mold_remediation.html.
9. Consider adopting the US EPA (2000b) document, "Tools for Schools", to maintain a good indoor air quality environment in the building. This document can be downloaded from the Internet at: http://www.epa.gov/iaq/schools/index.html.
10. Refer to resource manuals and other related indoor air quality documents for further building-wide evaluations and advice on maintaining public buildings. These materials are located on the MDPH's website at http://www.state.ma.us/dph/beha/iaq/iaqhome.htm.

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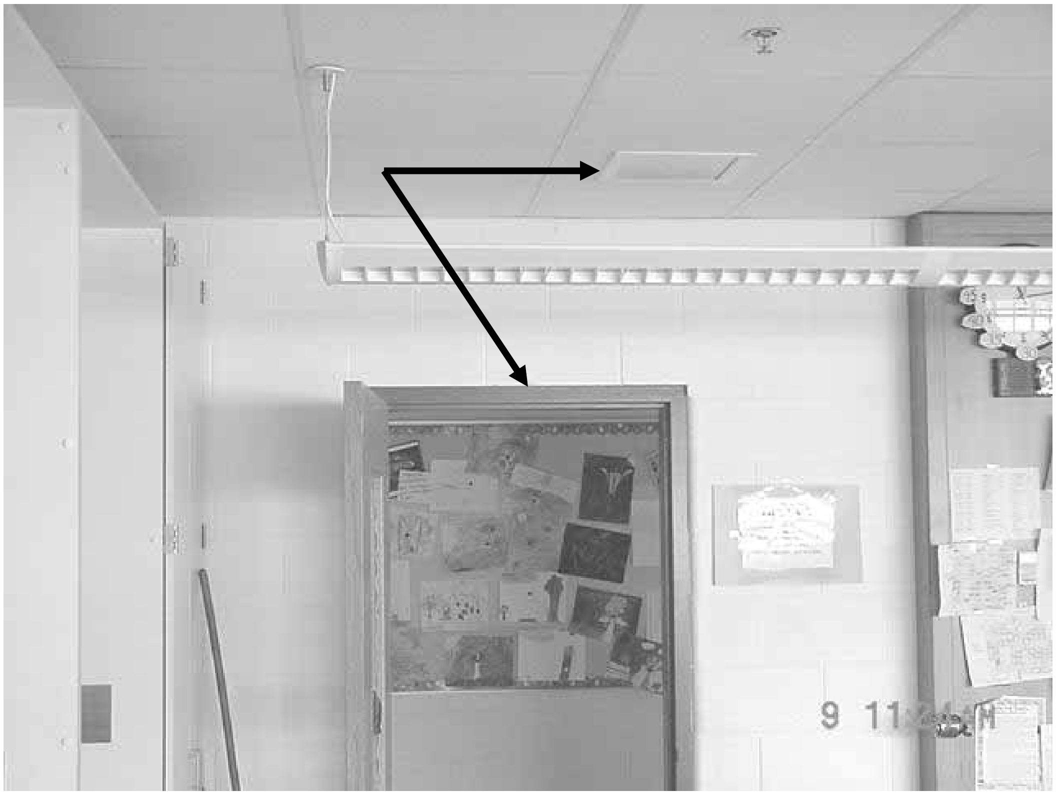
Picture 1

Classroom Univent

Picture 2

Univent Fresh Air Intake

Picture 3



Close Proximity of Ceiling-Mounted Exhaust Vent to Open Classroom Door

Picture 4

Interior of Cafeteria Door Sealed with Polyethylene Plastic Sheeting and Duct Tape

Picture 5

Exterior of Cafeteria Doors Sealed with Polyethylene Plastic Sheeting and Duct Tape

Picture 6

Outside Air Mechanically Introduced into the Hallway Adjacent to the Cafeteria via Flexible Ductwork

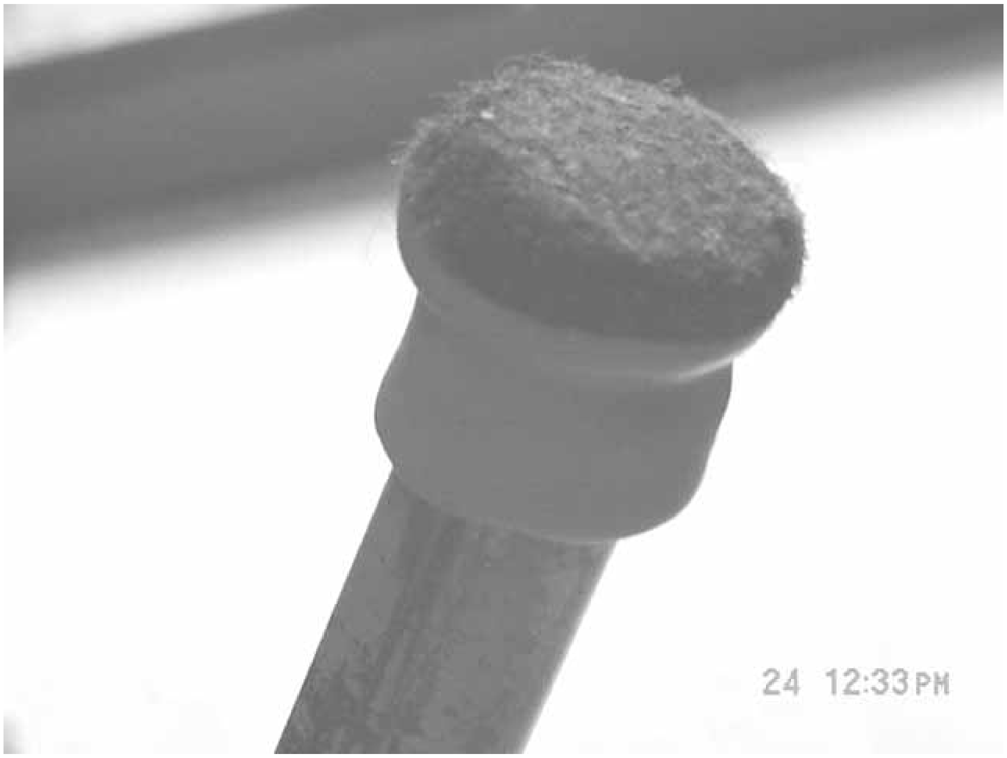
Picture 7

"Pressurized" Hallway Adjacent to the Cafeteria Note Ends of Flexible Ductwork Introducing Outside Air

Picture 8

Tennis Balls on Chair Legs

Picture 9



"Glides" for Chair Legs that can be used as an Alternative to Tennis Balls

Bryantville Elementary School | **Indoor Air Results**

29 Gurney Drive, Pembroke, MA 02359

Table 1

Date: 12/9/2004

Location	TVOC (ppm)	Occupants in Room	Windows Openable	Ventilation		Remarks
				Supply	Exhaust	
Outside (Background)	ND					Weather Conditions, cool, mostly sunny, winds: light and variable
Main Entrance Foyer	ND					Hallway entrance sealed with plastic- "pressurized"
Cafeteria Corridor	ND					Pressurized
Kitchen	ND		Y	Y	Y	Windows open
Cafeteria North	ND		Y	Y	Y	Heat and rubber-type odors, Ventilation on high heat to "bake out" VOCs
Cafeteria East	ND		Y	Y	Y	
Cafeteria South	ND		Y	Y	Y	
Cafeteria West	ND		Y	Y	Y	
Cafeteria Center	ND		Y	Y	Y	Doors sealed interior/exterior w/ plastic and duct tape
Cafeteria Stage	ND		N	Y	N	Supply vent-pressurizing stage area-exit to main foyer
201	ND		Y	Y	Y	Door open
202	ND		Y	Y	Y	
199	ND		Y	Y	Y	

Comfort Guidelines

Carbon Dioxide:	< 600 ppm = preferred	Temperature:	70 - 78 °F
	600 - 800 ppm = acceptable	Relative Humidity:	40 - 60%
	> 800 ppm = indicative of ventilation problems		

Location	TVOC (ppm)	Occupants in Room	Windows Openable	Ventilation		Remarks
				Supply	Exhaust	
198	ND		Y	Y	Y	
197	ND		Y	Y	Y	
194	ND		Y	Y	Y	
169	ND		Y	Y	Y	Door open
168 PT	ND		Y	Y	Y	
162	ND		Y	Y	Y	
Large Group Instruction	ND		Y	Y	Y	
Ensemble	ND		Y	Y	Y	
Music	ND		Y	Y	Y	
152	ND		Y	Y	Y	
151	ND		Y	Y	Y	
155	ND		Y	Y	Y	
142	ND		Y	Y	Y	

Comfort Guidelines

Carbon Dioxide:	< 600 ppm = preferred	Temperature:	70 - 78 °F
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Location	TVOC (ppm)	Occupants in Room	Windows Openable	Ventilation		Remarks
				Supply	Exhaust	
EIP	ND		Y	Y	Y	
138	ND		Y	Y	Y	
139	ND		Y	Y	Y	
136	ND		Y	Y	Y	
133	ND		Y	Y	Y	
Library	ND		Y	Y	Y	
127	ND		Y	Y	Y	
126	ND		Y	Y	Y	
121	ND		Y	Y	Y	
124	ND		Y	Y	Y	
122	ND		Y	Y	Y	
116	ND		Y	Y	Y	
119	ND		Y	Y	Y	

Comfort Guidelines

Carbon Dioxide:	< 600 ppm = preferred	Temperature:	70 - 78 °F
	600 - 800 ppm = acceptable	Relative Humidity:	40 - 60%
	> 800 ppm = indicative of ventilation problems		

Table 1

Location	TVOC (ppm)	Occupants in Room	Windows Openable	Ventilation		Remarks
				Supply	Exhaust	
114	ND		Y	Y	Y	
117	ND		Y	Y	Y	
PT Office	ND		Y	Y	Y	
Teacher's Planning	ND		Y	Y	Y	
Principal's Office	ND		Y	Y	Y	
Main Office	ND		Y	Y	Y	
222	ND		Y	Y	Y	
221	ND		Y	Y	Y	
224	ND		Y	Y	Y	
223	ND		Y	Y	Y	
226	ND		Y	Y	Y	
225	ND		Y	Y	Y	

Comfort Guidelines

Carbon Dioxide:	< 600 ppm = preferred	Temperature:	70 - 78 °F
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	> 800 ppm = indicative of ventilation problems		

Bryantville Elementary School **Indoor Air Results**

29 Gurney Drive, Pembroke, MA 02359 **Table 2** **Date: 01/19/2005**

Location/ Room	Occupants in Room	Temp (°F)	Relative Humidity (%)	Carbon Dioxide (ppm)	Carbon Monoxide (ppm)	TVOCs (ppm)	PM2.5 (µg/m3)	Windows Openable	Ventilation		Remarks
									Supply	Exhaust	
Background	0	20	17	370	ND	ND	23	N # open: 0 # total: 0			Comments : partly cloudy, SW winds 5-10 mph.
222	24	66	24	1072	ND	ND	18	Y # open: 0 # total: 6	Y univent wall	Y ceiling	DEM, TB.
221	0	71	17	850	ND	ND	16	Y # open: 0 # total: 6	Y univent wall	Y ceiling	Hallway DO; DEM, TB, Comments : 26 occupants gone 5-10 min.
224	25	72	15	753	ND	ND	18	Y # open: 0 # total: 6	Y univent wall	Y ceiling	DEM.
225	4	73	15	695	ND	ND	17	Y # open: 0 # total: 6	Y univent wall	Y ceiling	DEM.

ppm = parts per million
µg/m3 = micrograms per cubic meter

AD = air deodorizer
AP = air purifier
aqua. = aquarium

AT = ajar ceiling tile
BD = backdraft
CD = chalk dust
CP = ceiling plaster
CT = ceiling tile
DEM = dry erase materials

design = proximity to door
FC = food container
G = gravity
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NC = non-carpeted
ND = non detect
PC = photocopier
PF = personal fan
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sci. chem. = science chemicals
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VL = vent location
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Comfort Guidelines

Carbon Dioxide: < 600 ppm = preferred
600 - 800 ppm = acceptable
> 800 ppm = indicative of ventilation problems

Temperature: 70 - 78 °F
Relative Humidity: 40 - 60%

Bryantville Elementary School **Indoor Air Results**

29 Gurney Drive, Pembroke, MA 02359 **Date: 01/19/2005**

Table 2

Location/ Room	Occupants in Room	Temp (°F)	Relative Humidity (%)	Carbon Dioxide (ppm)	Carbon Monoxide (ppm)	TVOCs (ppm)	PM2.5 (µg/m3)	Windows Openable	Ventilation		Remarks
									Supply	Exhaust	
251	0	72	14	661	ND	ND	15	Y # open: 0 # total: 6	Y univent wall	Y ceiling	DEM, TB, aqua/terra, plants.
252	22	72	15	905	ND	ND	17	Y # open: 0 # total: 6	Y univent wall	Y	Hallway DO; supply blocked by clutter; DEM, TB, cleaners.
194	8	72	13	570	ND	ND	15	Y # open: 0 # total: 6	Y univent wall	Y ceiling	DEM, PF, TB.
193	22	73	16	1160	ND	ND	15	N # open: 0 # total: 0	Y univent wall	Y ceiling	DEM, TB.
192	23	72	14	760	ND	ND	14	Y # open: 0 # total: 6	Y univent	Y ceiling	Supply blocked by furniture; DEM, TB.

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									Supply	Exhaust	
191	0	70	16	865	ND	ND	15	Y # open: 1 # total: 4	Y univent wall	Y ceiling	cleaners.
Gym	20	69	13	549	ND	ND	14	N # open: 0 # total: 0	Y ceiling	Y wall	
169	0	70	14	652	ND	ND	15	Y # open: 0 # total: 6	Y univent wall	Y ceiling	Hallway DO; DEM, TB, Comments : 22 occupants gone 5 min.
162	20	71	15	627	ND	ND	13	Y # open: 0 # total: 8	Y univent	Y ceiling	DEM.
Music	22	71	15	884	ND	ND	18	Y # open: 0 # total: 6	Y univent wall	Y wall	DEM.

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									Supply	Exhaust	
152	7	72	14	520	ND	ND	17	Y # open: 0 # total: 2	Y univent wall	Y ceiling	DEM, cleaners.
E.I.P	4	75	13	572	ND	ND	13	Y # open: 0 # total: 2	Y univent wall	Y ceiling	DEM.
138	29	72	18	1538	ND	ND	19	Y # open: 0 # total: 4	Y univent	Y ceiling	Supply blocked by boxes and clutter; DEM, PF, TB.
Library	25	68	15	689	ND	ND	9	Y # open: 0 # total: 16	Y ceiling wall	Y ceiling	
126	22	71	17	908	ND	ND	17	Y # open: 0 # total: 4	Y univent wall	Y ceiling	DEM, PF, cleaners.

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29 Gurney Drive, Pembroke, MA 02359 | **Date: 01/19/2005**

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									Supply	Exhaust	
121	22	74	16	915	ND	ND	15	Y # open: 0 # total: 7	Y univent wall	Y ceiling	Window-mounted AC, DEM, cleaners.
124	20	74	17	971	ND	ND	17	Y # open: 0 # total: 4	Y univent	Y ceiling	DEM, PF, plants.
116	1	71	14	583	ND	ND	14	N # open: 0 # total: 0	Y univent	Y ceiling	Hallway DO; DEM, PF, plants, Comments : 21 occupants gone 30 min.
117	7	70	14	574	ND	ND	14	Y # open: 0 # total: 10	Y univent	Y ceiling	Supply blocked by furniture; DEM, plants.
Main Office	2	72	15	572	ND	ND	12	Y # open: 0 # total: 2	Y ceiling	Y ceiling	Hallway DO

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									Supply	Exhaust	
Principal's Office	1	74	14	504	ND	ND	14	Y # open: 0 # total: 2	Y ceiling	Y ceiling	

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